Asian Journal of Applied Science and Technology (AJAST)
Volume 7, Issue 2, Pages 136-150, April-June 2023

Comparative Studies of Biogenically Synthesized Selenium Nanoparticles Using Sweet Potato (*Ipomoea batatas*) and Coconut Water (*Cocos nucifera*) and Coating Them on Cotton Fabrics to Treat Mastitis Causing Bacteria

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DOI: https://doi.org/10.38177/ajast.2023.7216

Article Received: 05 April 2023 *Article Accepted: 17 May 2023* *Article Published: 31 May 2023*

ABSTRACT

Nanotechnology has built its application in numerous fields because of its high efficiency. It is an emerging field where novel ideas are being brought to make our life easier and better. Selenium is a micronutrient and it has a vital role in the metabolism of humans and other organisms. Its absorption and efficiency increase when they are in the form of nanoparticles. This work is about the synthesis of Selenium nanoparticles from sweet potatoes and coconut water by using the bio-synthesis method and coating them on cotton fabrics to treat mastitis. After the reduction of selenite, brick red coloured powder was observed. The UV spectrometry analysis was used to indicate the presence of Selenium. In biosynthesis, functional groups will remain in these nanoparticles. The morphological features of Selenium nanoparticles were studied using XRD, SEM and EDAX. The antioxidative and antimicrobial studies of these nanoparticles were examined.

Keywords: Selenium nanoparticles; Sweet potato; Coconut water; Biosynthesis; UV Spectrometry; XRD; SEM; EDAX.

1. Introduction

ASTM has recognized the particles which are having size ranging from 1-100 nm as nanoparticles [1],[2]. They have multiple application in different fields due to their particular properties like large surface area to volume ratio, crystallinity, solubility, functional groups, chemical composition, distinctive shapes etc. They are frequently used in the fields like cosmetics, paints, drug delivery, biosensors etc. Because of its distinctive physicochemical properties, it is capable of causing adverse effects on organs, tissues, cells, subcellular organelles, and DNA. So, its toxicity level is always analyzed. Selenium nanoparticles are used in this work. The word 'selenium' was taken from 'Selene', a Greek word which stands for their moon goddess. Jons Jacob Berzelius discovered it in 1818 [3], [4]. It is a metalloid element that occurs naturally and can be found in a variety of unprocessed substances, including air, water, soil, rocks, and animal tissues. It is an important microelement that is required for every living organism for their growth and development. It is an important element in biological bodies as they have vast significance in nutrition and medicine. The toxicity of selenium (selenosis) is found rare in humans. The concentration and chemical form of it determines its toxicity. These Se at the 0^{th} oxidation state (Se^0) has very low toxicity along with excellent bioavailability. However, among the most toxic compounds of selenium, the selenate and selenomethionine are the important ones. At the same time due to its insolubility selenium sulphide is much less toxic [5].

The Selenium nanoparticles have unique catalytic, photoreactive, biocidal, anticancer, and antioxidant properties. Because of this, it has increased its attention in the antimicrobial coating, nutritional supplements, diagnostics, medical devices, nanotherapeutics, etc [6]. Many kinds of research are concentrating on the drug delivery system, anticancer activity, antioxidative activity, and anti-inflammatory activity of selenium nanoparticles [6]. Nowadays

the anticancer therapy, biocidal activity, drug delivery, and antioxidant actions signify biomedical applications of selenium nanoparticles.

Elemental Se that is derived from biological sources occurs in the nanoform. Secondary metabolites produced by plants and bacteria were used to create the biological synthesis of selenium nanoparticles. Phenols and other alkaloids found in metabolites play a stabilizing and reducing role in the formation of NPs. The nanoparticles' level of toxicity might be reduced because of this [7]. Biological method is used for the synthesis here. The sources used in this work were Sweet Potato (*Ipomoea batatas*) extract and Coconut (*Cocos nucifera*) water. The synthesized nanoparticles are then tested for their antibacterial properties against the 2 bacteria that cause mastitis.

Mastitis is an infection in the mammary gland due to which inflammation occurs. The main factors that are found to be responsible for this condition are categorized into 3. They are environmental conditions, host resistance and the causative agents like bacteria [8]. About 33% of lactating women are suffering from mastitis and this condition is usually found during the first six months of postpartum.

The main reason for this is due to the milk stasis and infection [9]. It was proved by many scientists that most of the mastitis are caused by the change in microbiome in the mammary gland. *Staphylococcus aureus* is found to be the major etiological agent responsible for acute mastitis. The second most common bacterial species is *Streptococci*. For analysing the antibacterial property of the nanoparticles, *Staphylococcus aureus* and *Streptococcus mitis* were isolated and checked their zone of clearance after the application of Selenium nanoparticles (SeNPs). For treating this mastitis, the fabrics coated with these nanoparticles can be beneficial. The effectiveness of 100% cotton fabric coated with nanoparticles against the above-mentioned bacteria was studied in this work.

2. Materials and Methods

Fresh sweet potatoes (*Ipomoea batatas*) and coconuts, Sodium selenite anhydrous (Na_2SeO_3) (HIMEDIA). Magnetic stirrer, pH meter, centrifuge, Hot air oven, Weighing Balance were the equipments that were used for the experiment. Fabric of 100% cotton (white) was used for coating nanoparticles.

2.1. Synthesis of Selenium Nanoparticles

Sweet Potato Extract: 100 grams of sweet potatoes were weighed using a weighing balance. They were peeled of and washed twice with double distilled water. After that they were air dried to reduce the water content. The dried once were then grounded into powder form and stored in air tight container [10]. After mixing 5g of this powder with 100ml distilled water, a pale-yellow colour was observed in the solution. This solution was then boiled for 45 minutes. The solution got more viscous and darker after boiling. It was then filtered out using muslin cloth and then Whatman paper. This extract was used for the further processes [11],[10].

Coconut Water: The coconut water was taken from immature coconut. The extracted water was then collected in a beaker. Using a Whatman paper, this solution was filtered. The filtered water was then kept in an air tight container and then stored in a refrigerator.

The Selenium Nanoparticles were synthesized using these extracts. For that 30ml of distilled water containing Sodium selenite (0.1 mM) and Gallic acid (0.4 mM) were combined with 10ml of these extracts separately. Sodium

selenite was the metal salt that was used to synthesis selenium nanoparticles and Gallic acid is used as a catalyst [11]. The final solutions were then magnetic stirred for 2.5 hours at a 50ºC. The colour changed to dark brick red colour [10]. Centrifugation was done at 6000rpm for 30 minutes in these solutions to obtain the nanoparticles. The precipitates were collected. These pellets were then mixed with distilled water and then centrifuged to wash the pellets. These solutions were washed with distilled water twice [10]. These pellets were then dried in hot air oven at 60ºC for obtaining powdered form of these nanoparticles for the characterization analysis. The end product was found to be brick red coloured powder. Once these nanoparticles are dried then the nano system gets destroyed. So, only for the analysis purposes they were kept in powdered form.

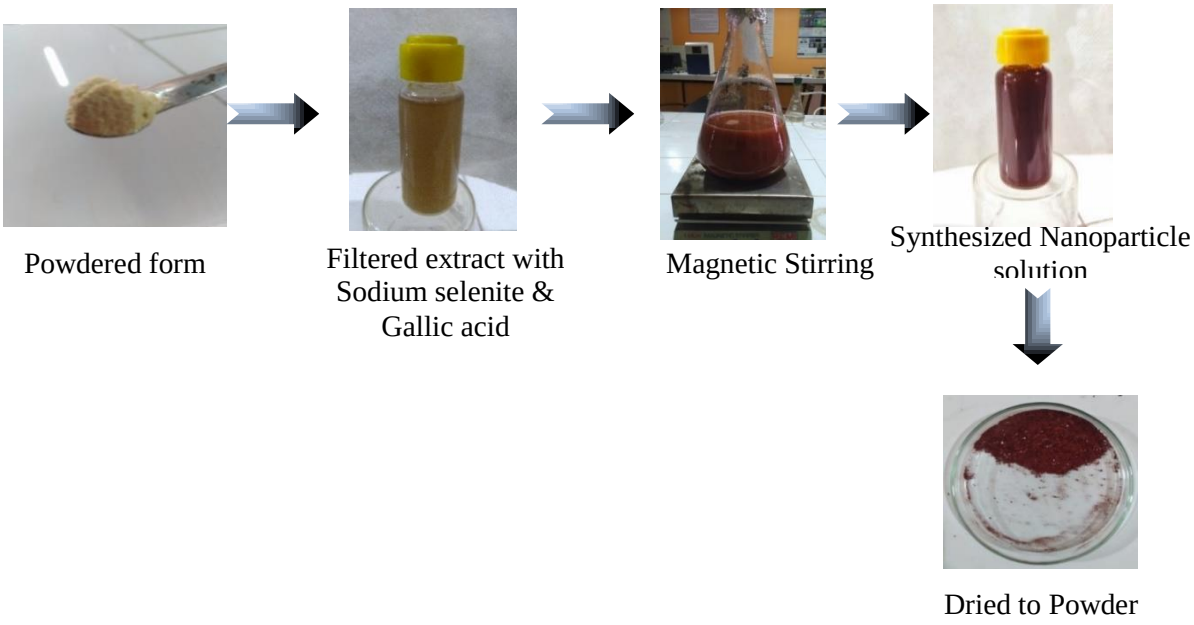

Figure 1. Steps in Selenium Nanoparticle Synthesis from Sweet Potato (SP-SeNPs)

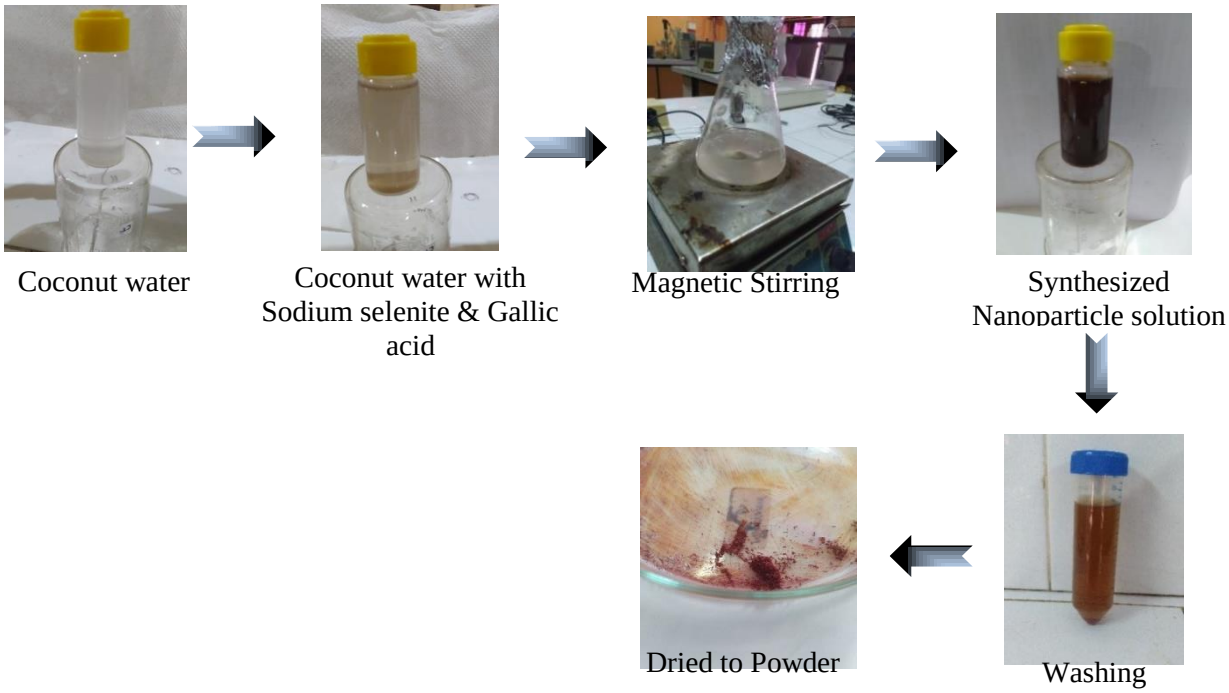

Figure 2. Steps in Selenium Nanoparticle Synthesis from Coconut Water (CW-SeNPs)

The detailed steps involved in the synthesis of SeNPs from Sweet Potato (SP-SeNPs) and Coconut Water (CW-SeNPs) are depicted in Figure 1 and Figure 2 respectively.

2.2. Coating on Cotton Fabrics

The 100% cotton fabric was taken and was dipped in an aqueous solution (30 ml) containing KOH (6 M). It was immersed in that solution for 5 minutes in room temperature. This was taken out and then rinsed with distilled water several times [12]. This was done before the nanocoating to impart absorbency [13]. The method used for coating was mechanical thermos fixation (pad- dry-cure method). The 2 pieces of dry cotton fabrics were dipped in 10ml of 50 mM Selenium nanoparticles concentrated solutions (SP-SeNPs & CW-SeNPs) separately. They were dipped in the solutions for 2 minutes. As a control, a piece of cotton fabric was kept in distilled water. They were then squeezed to reduce the water content. For drying and curing these fabrics were kept in hot air oven at 55 ºC for more than 2 hrs [14].

This process was repeated twice. The obtained fabric is Cotton-Se.

3. Characterization of Selenium Nanoparticles

The characterization of nanoparticles is essential to determine the morphological as well as the surface characteristics, which helps in investigating specific properties of the synthesized materials for different applications. The colour change in the solutions were observed initially. The synthesized nanoparticles were characterized by various methods and they are explained below.

3.1. UV-Visible Spectroscopy

Absorption spectroscopy in the ultraviolet-visible spectral band is known as UV-Vis spectroscopy. For the analysis, 3 ml of the suspension was taken from the purified sample and the spectra was studied over the region of 250-450 nm [15]. Thus, the synthesized nanoparticles were analyzed under UV-Vis spectrophotometer to determine their optical properties. The UV-Vis spectral analysis was performed by using a µ controller-based UV-Vis spectro-photometer 117.

3.2. Transmission Electron Microscopy (HR-TEM)

A beam of electrons is passed through a specimen to create an image using the microscopy technique known as transmission electron microscopy (TEM). The physical, chemical, and biological sciences all heavily rely on TEM as an analytical tool. As the beam passes through the object, the electrons' interactions with it produce the image that is ultimately seen. By direct visualisation, TEM provided a straightforward, clear-cut method for conclusively determining the shape, structure, size and morphology of the nanoparticles. Interior makeup of the sample is revealed in detail by TEM, including information on crystal structure, shape, and stress state. High Resolution TEM allows visualization of the atomic lattice in a crystalline material. The equipment used was JEM-2100 Electron Microscope**.** The suspension medium used for the analysis was distilled water.

3.3. Scanning Electron Microscopy (SEM)

High quality images of the samples were produced by the usage of the Scanning Electron Microscopy (SEM) technique. A small electron beam is passed across a sample and the signals emitted from it were observed in this

procedure. SEM is based on scattered electrons and concentrates on the surface and composition of the material. The sample's surface topography and chemical composition are revealed by the signals that were created as a result of the electrons' interactions with the sample's atoms. SEM analysis on the Selenium nanoparticle coated (SP-SeNPs and CW-SeNPs) and uncoated cotton fabrics were performed using JEOL - JSM-6390 - Scanning Electron Microscope. It was done to confirm the presence of nanoparticles on the fabrics

3.4. Energy Dispersive X-Ray (EDX)

This analysis is done to analyse the presence of a particular compound in a sample and also to confirm the purity of the sample. The composition of elements in the sample can be studied by EDX [11]. The SP-SeNPs and CW-SeNPs were analysed using the equipment OXFORD XMX N.

3.5. X-Ray Diffraction (XRD)

X-ray diffraction (XRD) is a quick analytical technique that may reveal the size of sample and is mostly used to determine the phase of crystalline materials. In this method, crystalline atoms cause an incident X-ray beam to diffract into numerous distinct directions. It gives angles for coherent and incoherent scattering from a crystal lattice. The basic principle behind this technique is Bragg's Law. The crystalline structure of the synthesized nanoparticles can be identified by XRD analysis with Bragg's angle ranging from 0º to 80º. The average size of the nanoparticle can be calculated using Debye-Scherrer equation. The equation is:

$$D=k\lambda/\beta\cos\theta \quad (1)$$

Where, the particle size (D) in nm is calculated using the X-ray wavelength (λ), FWHM(β), Bragg's angle of reflection in degree (θ) and Scherrer constant (k) whose value equals to 0.9.

The X-ray diffraction analysis was done using Bruker D8 Advance. The dried powder was examined at an applied current of 35.0 mA and accelerating voltage of 40.0 kV with wavelength λ=1.54060 Å at 2θ angle configuration. The anode material used in the analysis was Cu.

3.6. Fourier Transform Infrared Spectroscopy (FTIR)

An analytical method called FTIR is used to distinguish between organic and inorganic materials. The foundation of FTIR is the observation that most molecules absorb light most strongly in the infrared portion of the electromagnetic spectrum. The bonds in the molecule that are present correspond precisely to this absorption. On the surface of these nanoparticles, some functional groups may be present. The measurement of the vibrational frequencies of chemical bonds identifies these functional groups. These tests yielded molecular information that may be used to determine the conformational and structural alterations of the self-assembled functional groups [15]. The FTIR analysis of nanoparticle was performed in Nicolet iS50 FTIR Spectrometer. 400-4000 cm^{-1} was the wavelength range of the samples that were analyzed with a resolution of 4.000 to determine the possible functional groups that were present and also to determine the phytochemicals present in the plant extracts.

3.7. Antioxidant Activity

The antioxidant capabilities of selenium and its role as a vital element of antioxidant enzymes like glutathione peroxidase and thioredoxin reductase are the primary reasons for its significance in an organism [16]. To determine

the antioxidative property of SeNPs, the method of 2,2- Diphenyl picryl hydrazyl (DPPH) was applied [17][16]. DPPH and an antioxidant (H-A) can exhibit a scavenging reaction. Antioxidants interact with the stable free radical DPPH to convert it to DPPH-H. As a result, the absorbance from the DPPH radical to the DPPHH form decreases. The discoloration can be used to determine the antioxidant compounds' ability to donate hydrogen as well as to determine their degree of scavenging potential. 20mM and 50mM concentration of Se nanoparticles were prepared in distilled water. From these 2 solutions 50µL was taken separately in test tubes and to that 1 ml of DPPH (0.1mM) in methanol and 450µL of Tris HCl buffer (50mM) (pH 7.4) were added. These solutions were incubated in dark for 30 minutes [18]. As the control 20mM and 50mM gallic acid was used. 50µL of gallic acid was taken from each of these concentrations and kept separately in test tubes. Methanol was used as the blank. The free radicals present in the DPPH gets reduced by the materials having antioxidant properties. Thus, the free radical scavenging assay can be accomplished using the UV spectroscopy. This can be assessed by the absorbance at 517nm. The antiradical activity can be seen by lower absorbance in UV–vis spectroscopy[17]. The percentage of inhibition were calculated using the following equation.

$$\%\text{inhibition} = \frac{\text{Absorbance of control} - \text{Absorbance of test}}{\text{Absorbance of control}} \times 100 \qquad (2)$$

3.8. Antibacterial Properties

The major bacteria which are responsible for the disease mastitis are *Streptococcus* species and *Staphylococcus aureus.* Consequently, to analyse the antimicrobial property of Selenium nanoparticles on *Staphylococcus aureus* and *Streptococcus mitis*, 25mM and 50 mM concentrations were prepared in distilled water. The nanoparticles synthesized using Sweet Potato (SP-SeNPs) and Coconut water (CW-SeNPs) were used for this process. *Streptococcus mitis* and *Staphylococcus aureus* cultures were isolated from mastitis affected women's milk and cultured in nutrient broth for 24 hrs. After 24 hours, 50µl of these cultures were poured into nutrient agar plates for preparing spread plates. For the basic antibacterial property analysis disc diffusion method is used. The sterile discs (6mm) were dipped in 50 and 20mM concentration separately. They were then stirred at room temperature for 1 hr[19]. As the negative control, distilled water was used and as the positive control, chloramphenicol with 50ppm concentration was used. These discs were then placed on to the petri plates cultured with bacteria. The incubation of these petri plates were done at 37°C for 24 hours [20]. To analyse the zone of inhibition (ZOI) the clearing zones were measured around each disc.

3.9. Antibacterial Analysis on Nanoparticle Padded Fabrics

The fabrics were cut into $1cm^2$ for analysis. For sterilization, these fabrics were kept under UV light for 30 minutes. They were then placed onto the petri plates cultured with *Streptococcus mitis* and *Staphylococcus aureus* on nutrient agar. The incubation on these plates were done for 24 hours at 37°C, these plates were kept for incubation. After that their ZOI were calculated [21],[19].

4. Results and Discussions

4.1. Formation of Selenium nanoparticles

The formation of Selenium nanoparticles during biogenic synthesis could be visually observed on account of its optical properties. The colour change of the reaction mixture from yellowish brown to brick red after 2.5 hr of

homogenization represents the formation of Selenium nanoparticles. The change in colour can be observed in Figure 3.

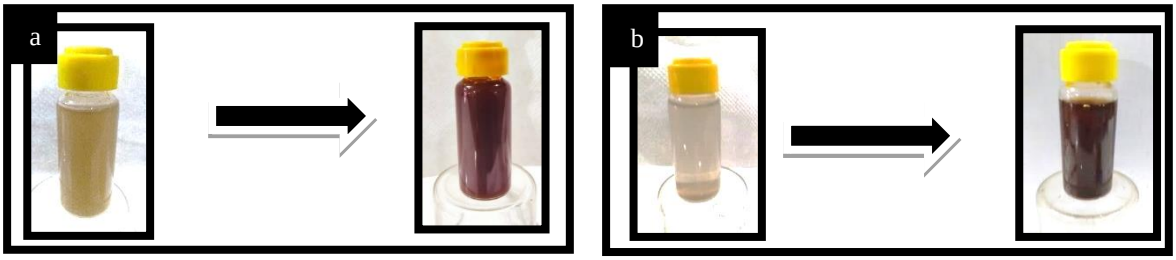

Figure 3. Colour change after magnetic stirring in **(a)** Sweet Potato extract, and **(b)** Coconut Water

When these nanoparticles were coated on the white cotton fabrics, the colour of the fabrics turned to brown. This colour change is shown in Figure 4.

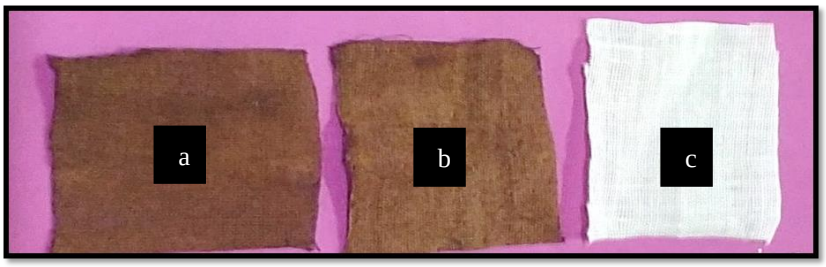

Figure 4. (a) Cotton Fabric coated with SP-SeNPs, **(b)** Cotton Fabric coated with CW-SeNPs, and **(c)** Uncoated Cotton Fabric

4.2. UV-Visible Spectroscopy

UV-Visible spectroscopy is generally performed to confirm the synthesis of Selenium nanoparticles. Figure 5 depicts the room temperature UV-Visible absorption spectrum of biosynthesized Selenium nanoparticles. At wavelength of 379.6l nm, the spectrum revealed a characteristic sharp absorption peak. This confirms the presence of Selenium nanoparticles [22],[23],[24].

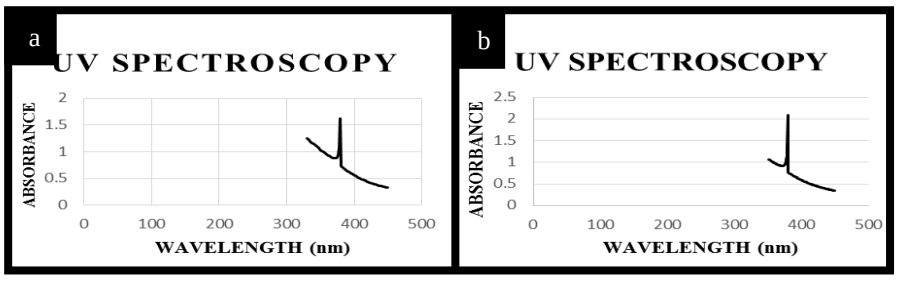

Figure 5. UV Visible spectrum of **(a)** SP-SeNPs, and **(b)** CW-SeNPs

4.3. Transmission Electron Microscopy (HR-*TEM)*

Transmission Electron Microscopic (TEM) images of SP-SeNPs and CW-SeNPs were obtained and are shown in Figure 6. The size of SP-SeNPs and CW-SeNPs were found to be between 80-90 nm and 72-81 nm respectively. The size of CW-SeNPs was comparatively low than SP-SeNPs. The variation in size of nanoparticles implied that these plant extracts could synthesize polydispersed nanoparticles [25]. The shapes of the nanoparticles were found to be in spherical and the agglomeration among the nanoparticles were found to be low.

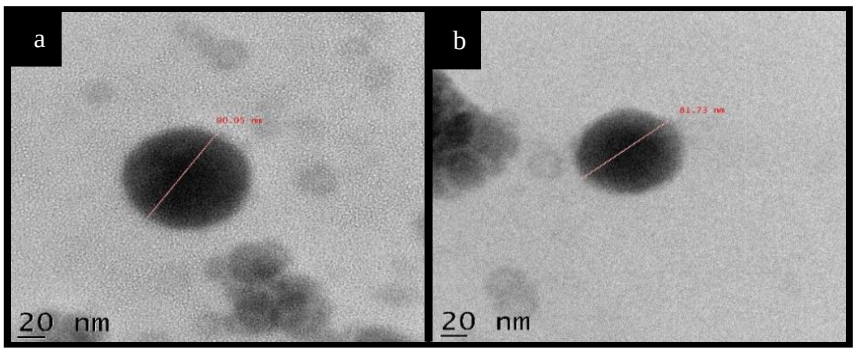

Figure 6. TEM image of **(a)** SP-SeNPs, and **(b)** CW-SeNPs

4.4. Energy Dispersive X-Ray (EDX) Spectrum

Energy dispersive X-ray (EDX) elemental mapping was derived from SP-SeNPs and CW-SeNPs. Their spectrums of SP-SeNPs and CW-SeNPs are shown in Figure 7(a) & (b) respectively. The elemental composition and impurities of these nanoparticles can be analysed from this spectrum. The weight percentage and atomic percentage of these nanoparticles are illustrated in the tables provided along with the spectrum. The spectrum showed a strong signal that corresponds to elemental Selenium at 1.37KeV [26].

Other elemental selenium peaks were found at 11.22KeV and 12.49KeV [27]. All the 3 peaks were found in both the spectrums. This confirmed that the selenium ions were bioreduced to elemental form. Peaks of other elements like Oxygen, Iron, and Sodium were found in SP-SeNP sample and Carbon, Oxygen and Copper were found in CW-SeNP sample.

These peaks are formed due to the presence of bio-active molecules that got attached to the surfaces of SeNPs during the bioreduction and stabilization process. These can be polysaccharides, phenolics, flavonoids etc [28]. From the table it can be concluded that the concentration of Se in the nanoparticles are more.

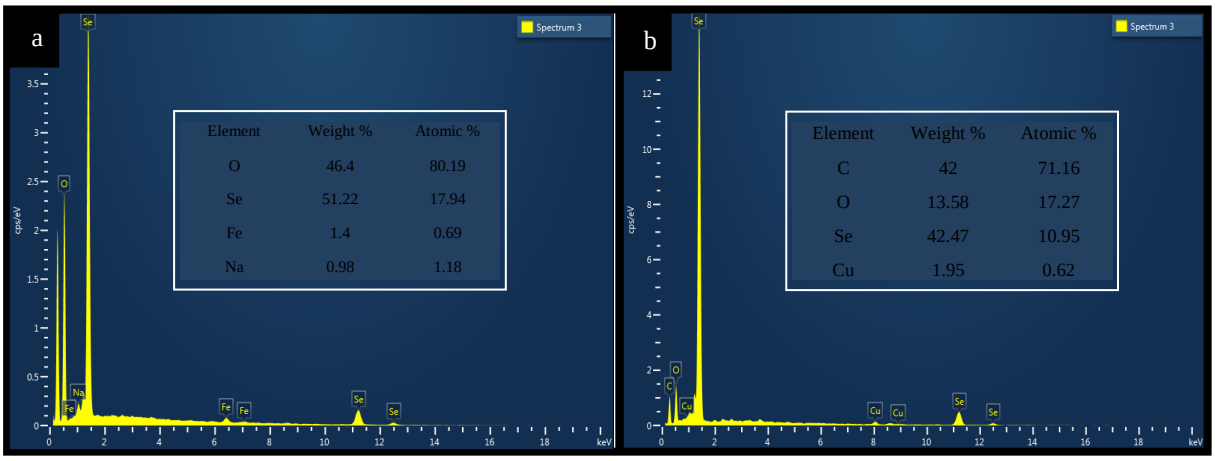

Figure 7. EDAX Spectrum of **(a)** SP-SeNPs, and **(b)** CW-SeNPs

4.5. X-Ray Diffraction (XRD)

X-ray diffraction (XRD) is a rapid analytical technique that is used for phase identification of a crystalline material. XRD pattern of biogenic Se NPs is shown in Figure 8 (a) & (b). Both the XRD patterns shows some disturbances which may be due to the bioactive compounds that were present in the plant extracts [22]. The Figure 8(a) which is

the XRD pattern of SP-SeNPs shows that there are 14 distinctive peaks (42.239°, 37.40352°, 32.641°, 31.617°, 27.978°, 25.354°, 24.350°, 19.714°, 19.107°, 16.161°, 14.594°, 14.377°, 12.554°, 11.868°). The average crystalline size was calculated using Debye-Scherrer equation and it was found to be 80.80996 nm. The distinctive peaks proved that the SP-SeNPs were crystalline [29] structure.

The Figure 8 which is the XRD pattern of CW-SeNPs shows that there are 2 peaks (27.814 °, 14.442 °) which are not distinctive. The peaks were broader without any sharp Bragg's peaks. The average crystalline size was 71.76966nm. The broad peaks proved that the CW-SeNPs were in amorphous structure [15].

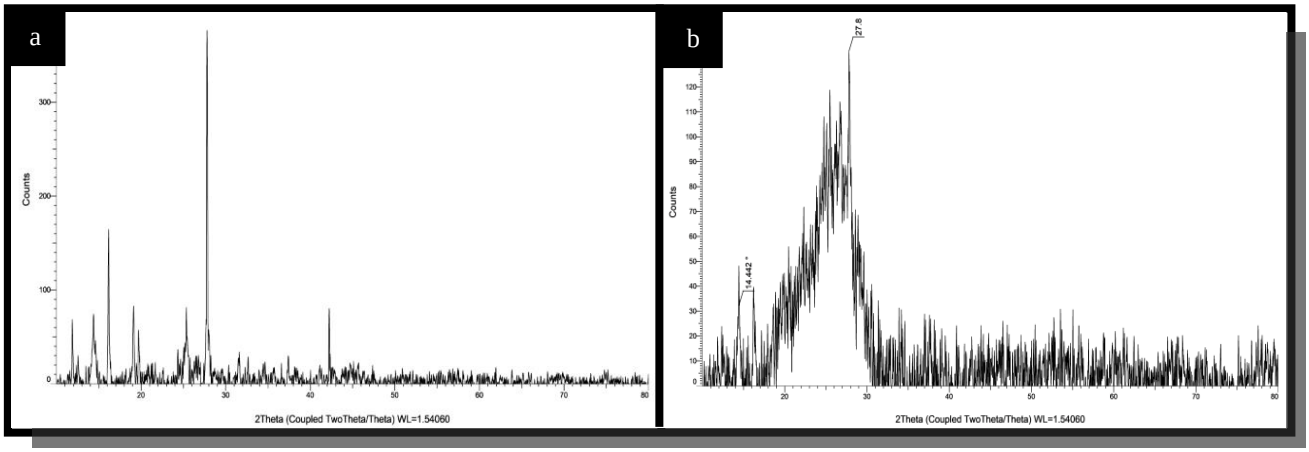

Figure 8. XRD pattern of **(a)** SP-SeNPs, and **(b)** CW-SeNPs

4.6. Fourier transform infrared spectroscopy (FTIR)

The Figure 9 shows the FTIR spectrum of SP-SeNPs and CW-SeNPs respectively. The figures show many peaks indicating the interaction of metal ion with biomolecules of SP-SeNPs and CW-SeNPs. A broad peak around the range 3400 cm^{-1} indicates the presence of O-H and N-H bonds. The O-H bonds can be from alcohol or acids. The N-H stretch is usually found at the region 3300-3500 cm^{-1}. C-N stretch is found at 1200- 1000 cm^{-1}.

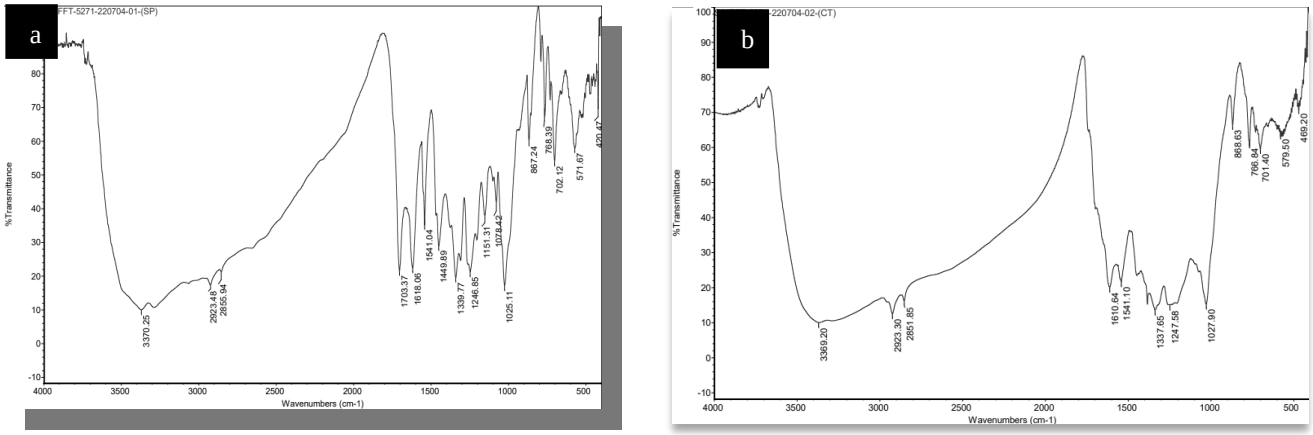

Figure 9. FTIR Spectrum of **(a)** SP-SeNPs, and **(b)** CW-SeNPs

The peaks found at the region between 2950-2800 cm^{-1} are due to the presence of alkanes. The C-H peaks are found in 2850-3300 cm^{-1}. The C=C bonds can be seen in the region 1700-1630 cm^{-1}. The presence of carboxylic acid can be determined by a distinctive shape where the strong and broad O-H peak joins with the C-H peak, the C=O peak

at 1730-1700 cm^{-1} and C-O peak at 1320-1210 cm^{-1}. In Figure 9 (a), the functional groups of SP-SeNPs are illustrated. The presence of carboxylic group can be confirmed by the distinctive peak. The alkane groups presence is also confirmed. The peaks between 1700 and 1630 cm^{-1} depicts the presence of alkenes in these nanoparticles. In Figure 9 (b), the functional groups of CW-SeNPs are illustrated. A broad and strong distinctive peak of carboxylic acid is visible here. The presence of alkene can also be confirmed from this spectrum.

4.7. Antioxidant Activity

Initially the colour of DPPH solution was violet but after the incubation, the colour changed to light yellow. The solutions were then checked for its absorbance. The solutions showed less absorbance as the concentration of SP-SeNPs, CW-SeNPs and gallic acid increased. The nanoparticles synthesized using sweet potato showed maximum antioxidative property. The % of inhibition calculated are shown in the graph below.

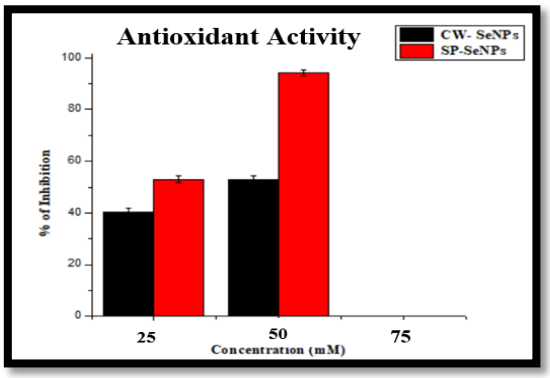

Figure 10. Graph representing the antioxidant activity at percentage of inhibition

4.8. Scanning Electron Microscopy (SEM)

The coated and uncoated fabrics were analyzed using SEM images. From the images, the surface of coated fabrics was rough in appearance while the uncoated fabrics were smooth. This depicted that the fabrics were coated with nanoparticles. The SEM images that were obtained are shown in Figure 11 (a), (b) & (c).

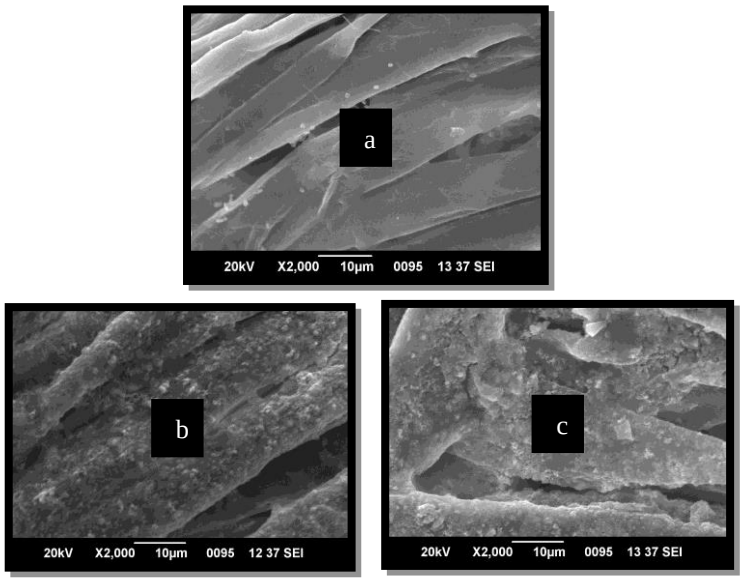

Figure 11. SEM image of **(a)** uncoated cotton fabric, **(b)** cotton fabric coated with SP-SeNPs, and **(c)** cotton fabric coated with CW-SeNPs

4.9. Antimicrobial Properties

The figures show the zone of clearance that were obtained by the application of SP-SeNPs and CW-SeNPs on the *Streptococcus mitis* and *Staphylococcus aureus.* The discs that were used had the diameter of 6mm. After 24 hrs, the zone of clearance was seen around all the discs except for the ones dipped in distilled water.

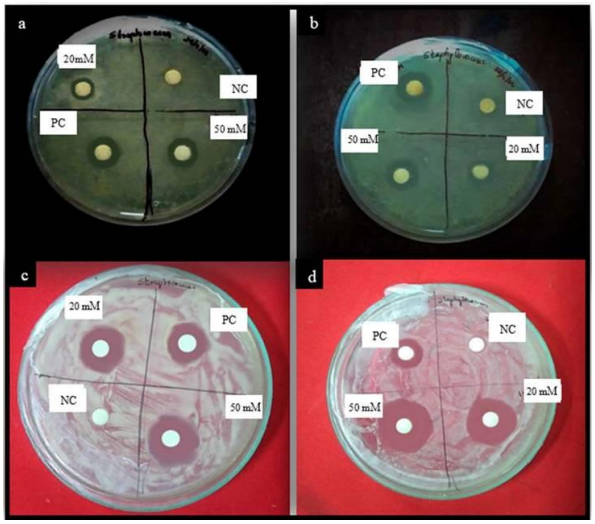

Figure 12. Zone of clearance in *Streptococcus mitis* using **(a)** SP-SeNPs, **(c)** CW-SeNPs and Zone of inhibition in *Staphylococcus aureus* using **(b)** SP-SeNPs, and **(d)** CW-SeNPs

Table 1. Zone of clearance in *Streptococcus mitis* and *Staphylococcus aureus* using SP-SeNPs

Name	Chemical	Concentration	Zone of Clearance (mm) *Streptococcus mitis*	Zone of Clearancece (mm) *Staphylococcus aureus*
PC	Chloramphenicol (Positive Control)	500ppm ($1.55x10^{-4}$ mM)	11±1.5	13±0.7
NC	Distilled water (Negative Control)	NA	6	6
50mM	SP-SeNPs	50mM	10	16
20mM	SP-SeNPs	20mM	8	10
50mM	CW-SeNPs	50mM	23	21
20mM	CW-SeNPs	20mM	20	18

Antibacterial property of fabrics coated with nanoparticles

Table 2. Zone of clearance in *Streptococcus mitis* and *Staphylococcus aureus* in SeNPs coated fabric

Name	Chemical	Concentration	Zone of Clearance (mm) *Streptococcus mitis*	Zone of Clearance (mm) *Staphylococcus aureus*
CW	CW-SeNPs	50mM	33	29
SP	SP-SeNPs	50mM	21	23
C	Distilled water	NA	10	10

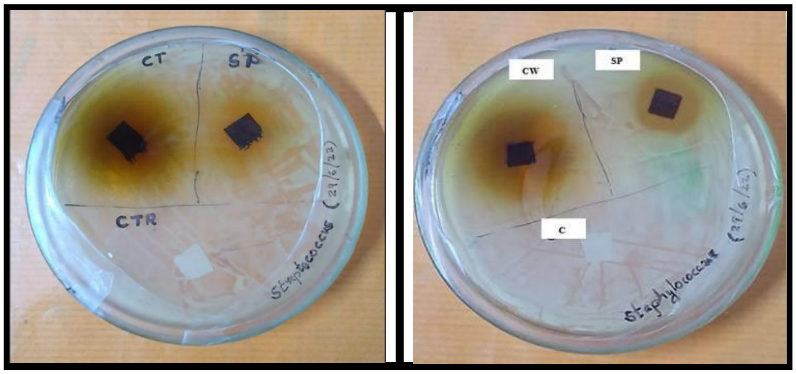

Figure 13. Zone of clearance in *Streptococcus mitis* and *Staphylococcus aureus* in SeNPs coated fabric

The Table 2 shows the antimicrobial effect of both CW-SeNPs and SP-SeNPs. The Zone of clearance of CW-SeNPs is comparatively more than SP-SeNPs. The coated fabrics are found to have more effect on *Streptococcus mitis* than in *Staphylococcus aureus.*

5. Conclusion and Future Aspects

Numerous uses for selenium nanoparticles are known, and new uses are always being developed. This work investigated the biosynthesis of SeNPs using sweet potatoes and coconut water. The process of creating nanoparticles by biosynthesis is safe, clean, simple, and stable for the environment. It was found that after magnetic stirring, the colour changed from light yellow to brick red as a result of the production of SeNPs.

Different methods were used to characterise the produced nanoparticles. The presence of Se NPs was confirmed by the peak in the UV-Vis spectrum at 379.6 nm. At the same time the XRD values showed that SP-SeNPs were in crystalline in structure and CW-SeNPs were in amorphous in structure. The Debye-Scherrer equation showed that the average size of these nanoparticles was 80.80996 nm and 71.76966 nm for SP-SeNPs and CW-SeNPs respectively. The sizes of SP-SeNPs and CW-SeNPs shown by TEM were between 80-90 nm and 72-81 nm respectively, which were similar to the XRD results.

The EDX values showed the concentration of Selenium in more in the samples. Though other impurities like Sodium, Iron and Oxygen were present in SP-SeNPs and Carbon, Copper and Oxygen were present in CW-SeNPs. The FTIR results showed the presence of Carboxylic acid, alkenes and alkanes in both the NPs. The antioxidative property was analyzed using DPPH method and the antioxidative property of SP-SeNPs were found to be more compared to CW-SeNPs. The antimicrobial effect on *Streptococcus mitis* and *Staphylococcus aureus* were analysed using CW-SeNPs and SP-SeNPs with the help of disc diffusion method.

The SeNPs coating on 100% cotton fabric (white) was done by pad-dry-cure method. The colour of the fabrics turned into brown. The antibacterial property of these padded fabrics was analysed and found to have good antibacterial property towards *Streptococcus mitis* than in *Staphylococcus aureus.* These 2 bacteria are the common cause of mastitis in women. Since these nanoparticles have antibacterial property against these bacteria, these padded fabrics can be used to treat mastitis in women. But a proper cytotoxic study is yet to be studied on mammal cells to know the feasibility of these padded fabrics. Along with that the physical and mechanical studies on the fabrics are to be done for the commercialization.

Declarations

Source of Funding

This study did not receive any grant from funding agencies in the public or not-for-profit sectors.

Competing Interests Statement

Authors have declared no competing interests.

Consent for Publication

The authors declare that they consented to the publication of this study. The work have been submitted for publication with due consent of authorities of their institutes.

Ethical statement and Conflict of interest

The work presented here does not involve any experiment with human or animals. The authors declare that they do not have any conflict of interest.

Authors' Contributions

All authors equally participated in research and drafting the manuscript.

Acknowledgements

The authors acknowledge Sophisticated Tests and Instruments Centre, Cochin University, Ernakulam, Kerala and CSIR NIST, Thiruvananthapuram, Kerala for providing facilities for the nanoparticle analysis. The authors are also thankful to Sree Buddha College of Engineering, Pattoor, Kerala for the technical and laboratory support.

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